WHAT IS CLAIMED

1. A method of determining time-dependent changes in sub-surface density of a natural resource reservoir, comprising the steps of:

obtaining a set of time-lapse gravity gradient data for a sub-surface natural resource deposit characterized by a change in a density characteristic over time;

creating a model of the change in density of the reservoir having a plurality of volume elements therein, including constraints on the model;

establishing a set of quantized mathematically related parameters defining the density model and computing at least gravity gradients for that quantized model and computing a corresponding figure of merit therefor;

perturbing at least one parameter of the model and recalculating the figure of merit for the perturbed model;

evaluating the figure of merit for the perturbed model relative to that of the immediately preceding model and accepting the perturbed model if more optimal relative to the immediately preceding model and accepting the perturbed model if less optimal in accordance with a probability function that varies in accordance with a control parameter; and

repeating the perturbing and evaluation steps while the control parameter decreases the probability function with successive repetitions.

2. The method of claim 1, wherein the gravity gradient data includes at at least the $U_{xx} - U_{yy}$ and $2U_{xy}$ components.

3. The method of claim 1, wherein the time-lapse data sets

include at least the positional coordinates for a plurality of measurement sites, time-lapse gravity gradient data at each site, and the time between measurements.

4. The method of claim 1, wherein the model is a two-dimensional variable-depth column model.

5. The method of claim 1, wherein the model is a right parallelipiped of stacked prisms arranged in a rectangular grid pattern.

6. The method of claim 1, where said constraints are implemented by a penalty function.

7. A method of identifying the boundary or interface between a driveout fluid and to-be-recovered oil in a sub-surface oil reservoir undergoing secondary oil recovery, comprising the steps of:

measuring the gravity gradient at a plurality of observation sites associated with the oil reservoir over a period of time to obtain time-displaced gravity gradients associated with each observation site;

creating a change of density model of the oil reservoir having a plurality of volume elements therein, including constraints on the model;

establishing a set of quantized mathematically related parameters defining the density model and computing at least gravity gradients for that quantized model and computing a corresponding figure of merit therefor;

perturbing at least one parameter of the model and recalculating the figure of merit for the perturbed model;

evaluating the figure of merit for the perturbed model relative to that of the immediately preceding model and accepting the perturbed model if more optimal relative to the immediately preceding model and accepting the perturbed model if less optimal in accordance with a probability function that varies in accordance with a control parameter; and

repeating the perturbing and evaluation steps while the control parameter decreases the probability function with successive repetitions.

8. The method of claim 7, wherein the gravity gradient data includes at at least the $U_{xx} - U_{yy}$ and $2U_{xy}$ components.

9. The method of claim 7, wherein the time-lapse data sets include at least the positional coordinates for a plurality of observation sites, time-lapse gravity gradient data at each site, and the time between measurements.

10. The method of claim 7, wherein the model is a two-dimensional model defining a rectangular array of columns, each having a depth variable, each columns defining a volume element.

11. The method of claim 7, wherein the model is a right parallelipiped of stacked prisms arranged in a rectangular grid pattern, each prism defining a volume element.

12. The method of claim 7, wherein the set of quantized mathematically related parameters are functionally related to the changes in saturation of the oil and the driveout fluid in each volume element.

13. The method of claim 7, where said constraints are implemented by a penalty function.